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Biology Teaching – Urgent Need for an Integrative Approach

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Biology started as a descriptive science. However, with increasing adoption of experimental approaches since the later part of 19th century, Biology was also as much experimental by the middle of the 20th century as the “physical” sciences. This encouraged physicists and chemists to also inquire into the nature of life. Non-biologists like Niels Bohr, Max Delbruck, E. Schrodinger, Francis Crick and others dramatically changed the nature of Biological studies. These and other developments in fields of Genetics and Biochemistry catalyzed the birth and subsequent rapid development of Molecular Biology. With an increasing number of non-biologists contributing to our understanding of “what is life”, the panorama of biological studies has greatly expanded not only horizontally (i.e., interfacing with other science disciplines) but also vertically (i.e., to deeper levels in biological organizations). The 20th Century witnessed most remarkable and exciting developments in biological sciences. Thanks largely to the progress in Genetics and related basic and applied areas, Biology will continue to dominate at least the first few decades of the 21st Century. The maddening drive to understand the “molecular” basis of life and the reductionist approach has helped unravel many secrets of life and this has opened newer and very powerful ways to exploit the biological wealth. Thus the excitement in Biology is not only from the basic science point of view but also because of the biotechnological applications.

In view of the spectacular success of the molecular approaches in Biology, Molecular Biology has become the “in” thing, which most students want to study and pursue. It may, however, be noted that molecular Biology is, at best, an approach to studying the biological phenomena; it is not as well defined a sub-discipline as fields like taxonomy, ecology, physiology, cytology, genetics and so on. Nevertheless, the all pervasive influence and “glamour” of molecular Biology have resulted in a somewhat skewed emphasis on certain aspects of Biology at the cost of others.

Specialists concentrate in narrower and narrower areas of inquiry. As the knowledge in each of the sub-branches of Biology increased, the inter-branch communication declined. The biological organism was often not the subject of

study; individual molecules and systems gained more importance for the researchers. This resulted in an unhealthy dichotomy between “Traditional” or “Classical” and “Modern” or “Molecular” Biology. The latter places emphasis on “biochemical” or “molecular” reductionist approach to biological issues, often without a reference to the organism. In the midst of euphoria over “molecular Biology”, the disciplines that deal with whole organisms have generally been branded as “classical” and, therefore, have often been not only ignored but even looked down upon. The conflict between “modern” and “classical” Biology is apparent in research programs as well as in the teaching curricula.

Conflict between “Classical” and “Modern” Biology Teaching

In terms of the curricula being followed at under- and post-graduate levels, the programs of Biology teaching in different institutions in our country may be grouped as follows:

- Curricula where age-old things continue to be taught (teachers use their own student days’ notes!)
- Curricula where only the “latest” is taught, ignoring the basics that are considered “classical” and therefore, unnecessary
- Curricula with generally updated contents and a reasonable balance between “classical” and “modern” subjects

The last category is very rare.

Subjects like Classification/Taxonomy, Morphology, Anatomy etc have often been labeled as “classical” as opposed to “modern” subjects like Molecular Biology, Biochemistry, Genetics, Biotechnology etc. Such “modern-looking” programs have become popular because they tend to fetch better grants and better “respect”. There is no denying that the new teaching programs in “modern” Biology have been useful in several respects. But the over-emphasis on “modern” Biology has belittled the importance of traditional Biology departments. A contempt for “classical” Biology has also sometimes been notable in the decision-making and influential quarters. However, it must be noted that the so-called “classical” subjects themselves have not become irrelevant in the present context, but it is the content and the manner of teaching of these subjects that have made them “archaic” rather than “classic”. Actually, “classical” should always remain “classy”! To cite an example, taxonomy is one area that has suffered considerably. Lack of competent taxonomists in the country is now being felt in every quarter, especially in relation to assessment and conservation of the biological diversity in the country. In the context of biotechnological applications and threats of intellectual property rights, the country today is in a very disadvantageous position. This sorry state of affairs has come to be primarily due to the continued teaching of archaic information in an unstimulating manner and to some extent

also due to a contempt for taxonomy in the minds of many "modern" Biologists. Appropriate integration of informations available from advances in molecular genetics, developmental biology, evolution, comparative physiology, anatomy etc, can make the field of taxonomy as vibrant and interesting as any other. Therefore, what we need is a change in contents of the so-called "classical" sub-disciplines and change in our attitude and approach to their teaching.

The "glamour" and the supposedly better promise for future, attract brighter students to the "modern" courses. Unfortunately, however, these "modern" courses have been introduced at most places without adequate training of teachers and without the minimal laboratory facilities. Consequently, while the departments and faculty claim "modern", and, therefore, respectable status, the students often learn neither the "classical" ("organismic") nor the "modern" ("molecular Biology") Biology adequately. Disillusionment of students is, therefore, not unexpected. On the other hand, the traditional departments, starved of bright and eager students and of funds are in deep despair. If the teachers also lose their enthusiasm, which is not an unlikely event when grants are limited and eager students are not awaiting in classrooms, such departments enter a degenerative path. Such places fail to attract brighter faculty members also. The decline in reputation of many departments of Zoology, Botany or Microbiology etc in different universities in the country, which once upon a time were considered "very strong" and leading departments, reflects this alarming situation.

Thus in the present situation, while the once "strong" departments are decaying, the new ones are, in most cases, without the basic minimal infrastructure (manpower and material facilities). This alarmingly critical situation needs urgent correction.

Rigid Compartmentalizations Lead to Fragmented Teaching

The rigid compartmentalization in our Biology teaching programs is responsible for producing graduates with a grossly inadequate background in Physics and Computer applications (fortunately, Chemistry is often, though not always, one of the subjects at the under-graduate level). Likewise, students opting for "Physical Sciences" are mostly not exposed to Biology. In addition, the apparently invincible boundaries between the traditional Biology department (like Botany, Zoology, Microbiology etc) cause fragmented teaching of common biological themes. Thus common disciplines like Genetics, Biochemistry, Ecology, Evolution etc are taught in piecemeal manner in each of these departments. As a result, the students often fail to appreciate the commonality between the different biological systems.

Our system debars students from any inter-disciplinary study and learning. Likewise, nearly all of the research programs in biological sciences remain confined to narrow fields without a serious attempt to make an integrated

approach. As a consequence, such isolated endeavors do not make the desirable impact that may have been possible with an integrated approach.

Need for Integrative Biology

During the course of the past few decades, there has been an unprecedented explosion in the knowledge and understanding of biological systems; the range of biological systems has also widened, extending from populations to molecules and atoms. Therefore, it is necessary that a student of Biology today is exposed to a holistic view. To achieve this, the International Union of Biological Sciences (IUBS) has adopted a new program named "Towards an Integrative Biology" (TAIB) to restore balance between the various approaches to the study of living systems and to take advantage of the power of Genetics, Molecular Biology, information technology, sophisticated instrumentation etc to understand life at all levels.

While "traditional" Biology employs specific approaches and techniques to study different levels of biological organization, "modern" Biology places an over-emphasis on "biochemical" or "molecular" and reductionist approach to biological studies, neglecting the organisms and their diversity. In contrast, Integrative Biology seeks both the diversity and integration or incorporation

Integrative Biology is not a new subject or discipline but is only an approach to learn and study the diversity of biological organizations in a holistic manner.

Integrative Biology may mean different things in different contexts:

- Multi-disciplinary or cross-disciplinary or trans-disciplinary approach to include incorporation of Physics, Chemistry, Engineering, Information Technology, Sociology, Economics etc
- Use of diversity of techniques to address a question
- Hierarchical approach (from populations to individuals and from organism to molecules) to questions and techniques

As stated by Prof. M. H. Wake (President, IUBS) "Integrative Biology provides both a philosophy and a mechanism for facilitating science at the interfaces of 'horizontally' arrayed disciplines, in both teaching and research".

Biology in the new millenium needs an integrative approach, an integration within the discipline (intra-Biology integration) and integration between disciplines (integration with other branches of Science). This requires not only a balance between the so-called "classical" and "molecular" Biology but it also requires that students of Biology are not debarred from studying Physical sciences and vice-versa. A modular system of courses that allows enough plasticity in choosing course modules as per interests and requirements is essential to produce new generations of students, teachers and researchers who can fully appreciate and take advantage of the exciting developments in Biology that are awaited in the new millenium.